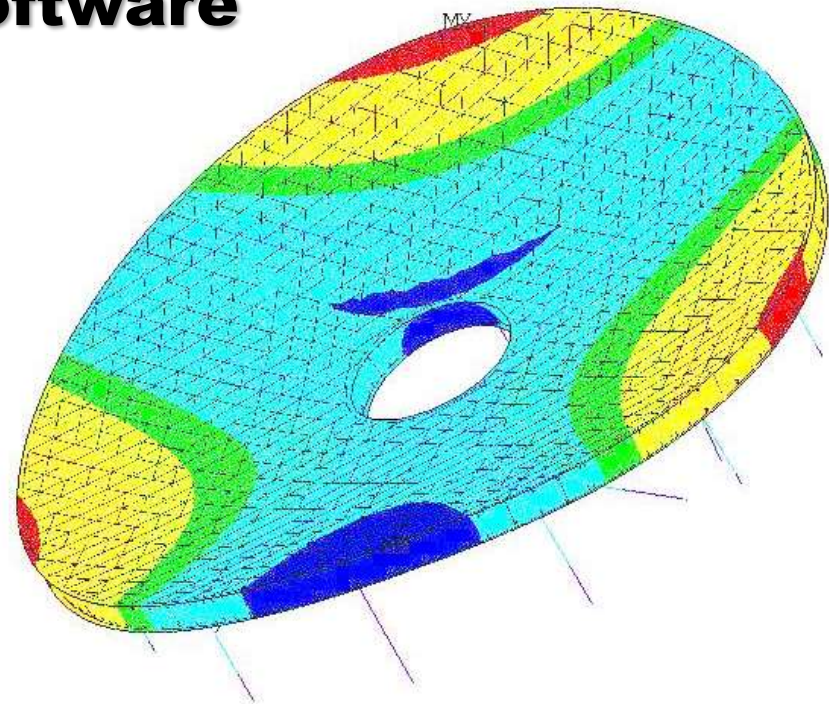
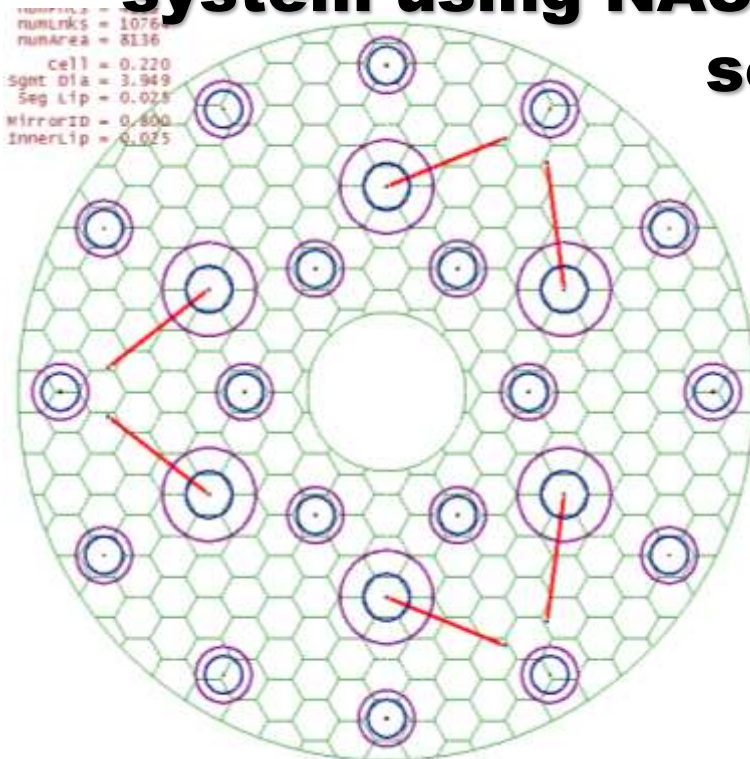




# Integration of mirror design with suspension system using NASA's new mirror modeling software



William R. Arnold Sr., Sr. Principal Engineer, DAI, Huntsville, AL.  
Ryan M. Bevan, NASA Intern, NASA MSFC, Huntsville, AL.  
Dr. Phil Stahl, AMTD PI, NASA MSFC, Huntsville, AL.

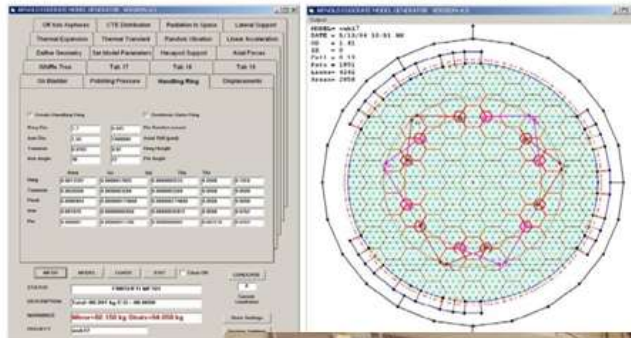
# **INTRODUCTION**

## **TOOLS FOR INTEGRATED DESIGN OF MIRRORS & SUSPENSION SYSTEMS**

- **WHY WE ARE INTERESTED IN THESE TOOLS**
  - **LARGER SPACE-BASED UV TELESCOPES BEING PLANNED.**
  - **LAUNCH CAPABILITIES REMAIN UNCERTAIN**
  - **COST & SCHEDULE TO BUILD COMPLEX FEM MODELS**
  - **THIS APPROACH WAS VERY SUCCESSFUL ON KEPLER**
- **SUBSTRATE MATERIALS & FABRICATION ADVANCES**
  - **ULE (FRIT OR LOW TEMPERATURE FUSION)**
  - **ZERODUR (POCKET MILLED & ACID)**
  - **BOROSILICATE (CAST)**
- **SUSPENSION SYSTEMS & LIGHTWEIGHT OPTICS**
  - **OPERATIONAL (KINEMATIC)**
  - **AUXILLARY LAUNCH (DISENGAGES ON ORBIT)**
  - **HOW MIRROR DESIGN INTERACTS WITH SUSPENSION(S)**

# INTEGRATED APPROACH TO DESIGN (PREDECESSOR PROGRAM USED ON KEPLER)

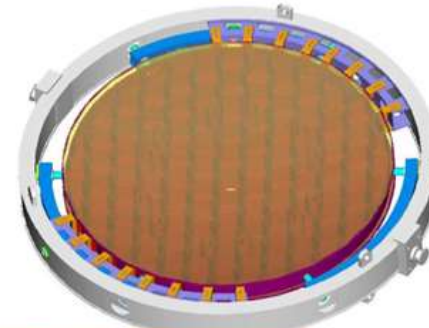
Integrated Design of Handling Equipment



Design tool allows evaluation of the mirror blank. As mirrors manufacturing requires careful were added to the blank specific

Kepler

Primary Mirror in Flipping Ring



enforced slots in the mirror the unit can act as a l surfaces or fragile edges

2004



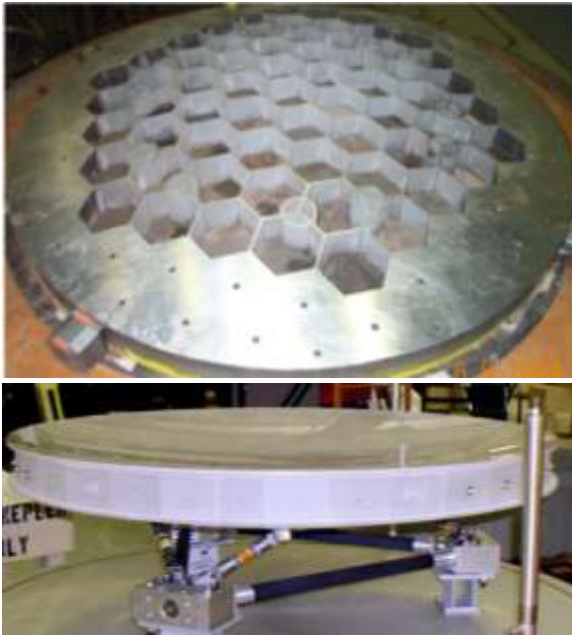
# **STEPS IN A BASIC MIRROR DESIGN TRADE STUDY**

- **EVALUATE MATERIALS AND CONSTRUCTION**
  - MASS, COST, RISK, SCHEDULE ... LOOK AT SEVERAL CHOICES
- **MIRROR ONLY PERFORMANCE (MODES, WEIGHT)**
  - GET FEEL FOR GEOMETRIC & THICKNESS INFLUENCES
- **MIRROR & OPERATIONAL SUPPORT**
  - MODE SHAPES, FREQUENCIES (ON ORBIT BEHAVIOR)
- **MIRROR, OPERATIONAL & AUXILIARY SUPPORT**
  - LAUNCH CONDITIONS, MIN FREQ, LOCAL STRESSES, ETC
- **OPTIMIZE GEOMETRY, THICKNESS, ETC**
  - CELL SIZE, EDGE ZONES, LOCAL REINFORCEMENT, CONSTRUCTION

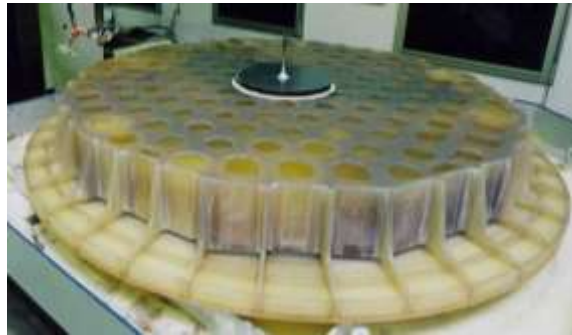


# MATERIAL CHOICE DICTATES CONSTRUCTION METHOD

FRIT BONDED ULE



POCKET MILLED ZERODUR



CAST BOROSILICATE

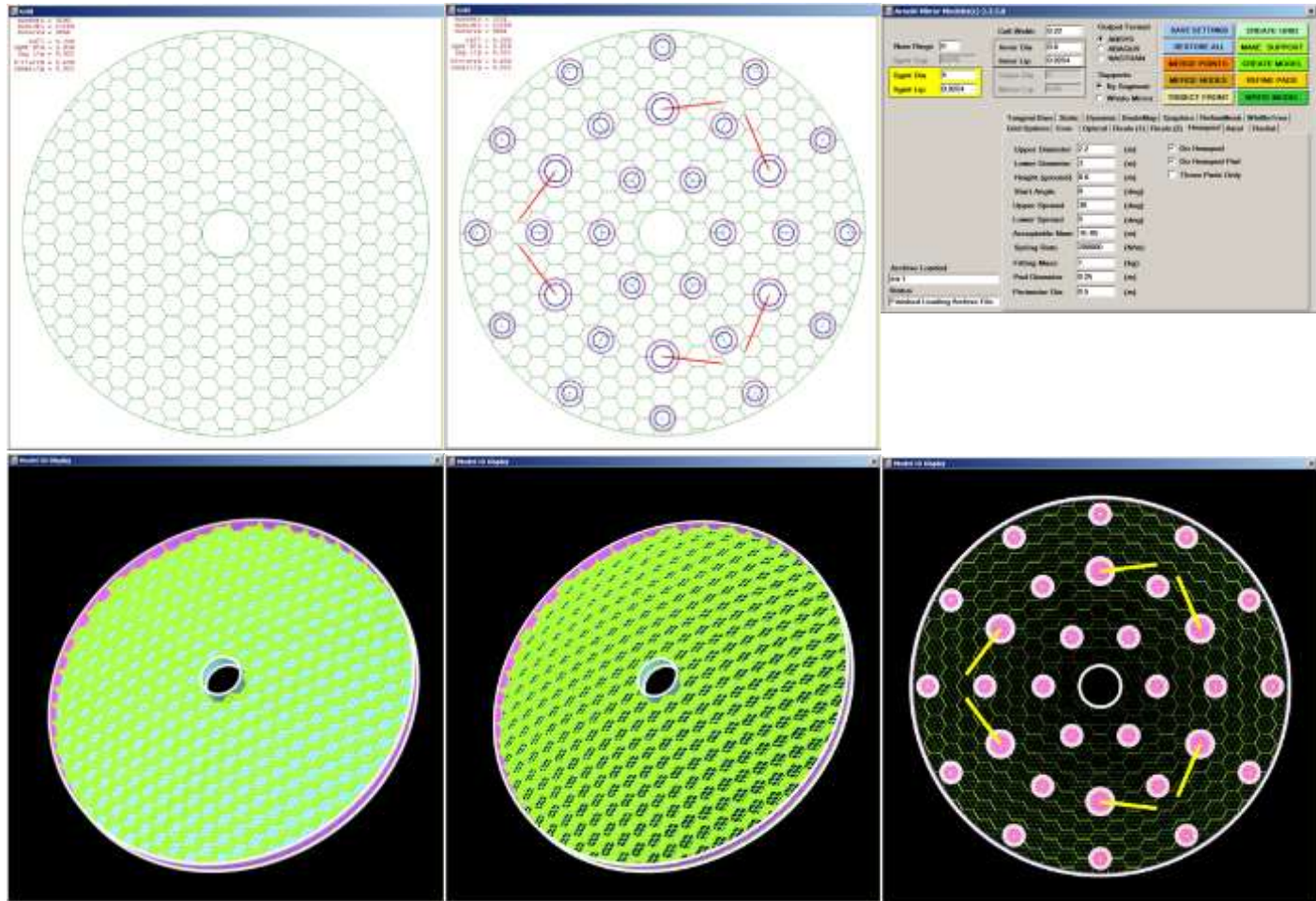


**\*LOW TEMPERATURE FUSION IS AN  
ALTERNATIVE ASSEMBLY, REQUIRES SLUMPING**

# QUICK INTRO TO MODELER



# ONE GRID PATTERN CAN CREATE MANY VARIATIONS

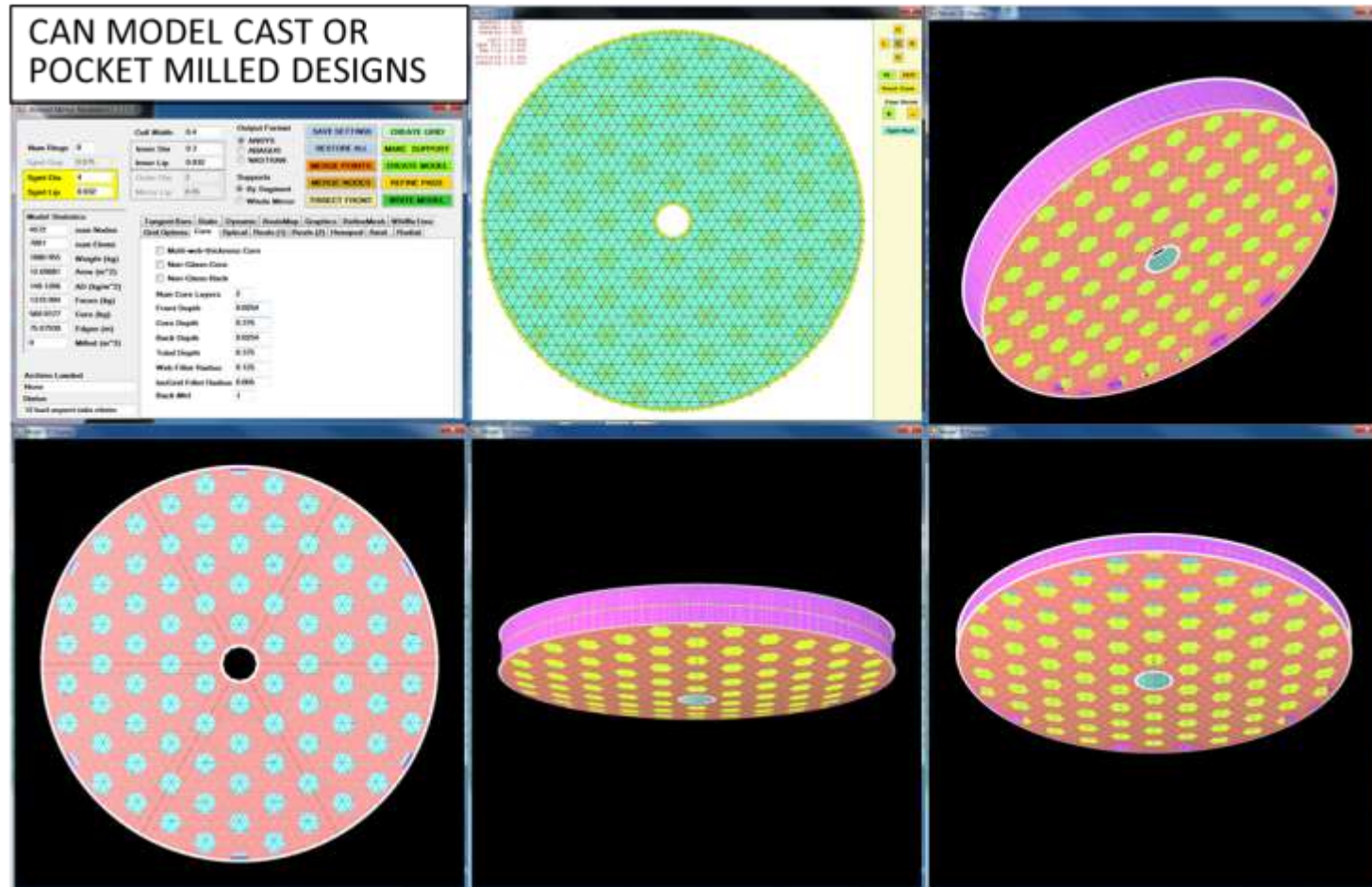




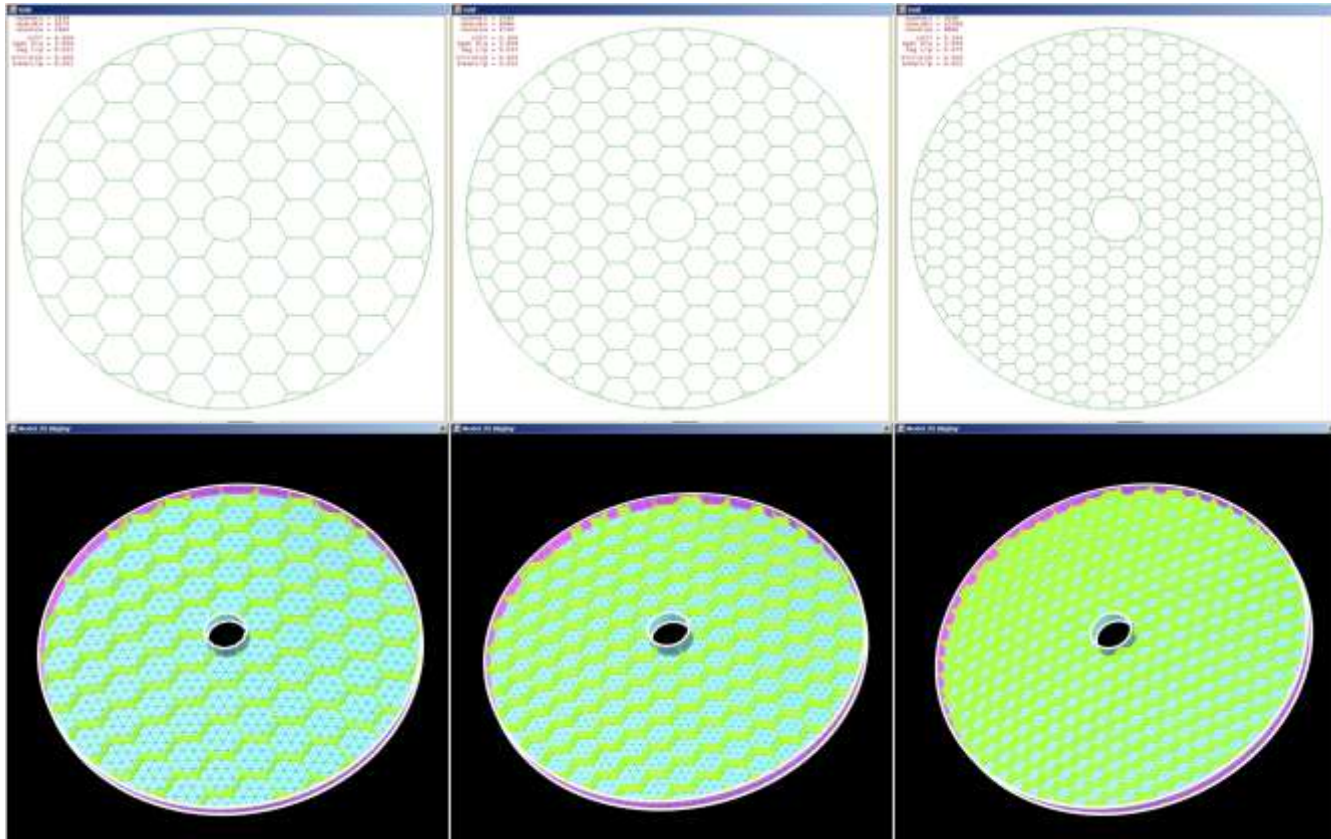
# **QUICK EXAMPLE OF TRADE STUDY USING THE MODELER**



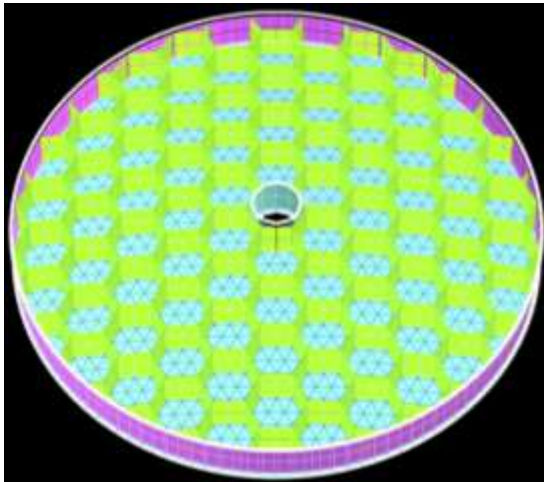
# STEP 1 - EVALUATE MATERIAL CHOICES & CONSTRUCTION



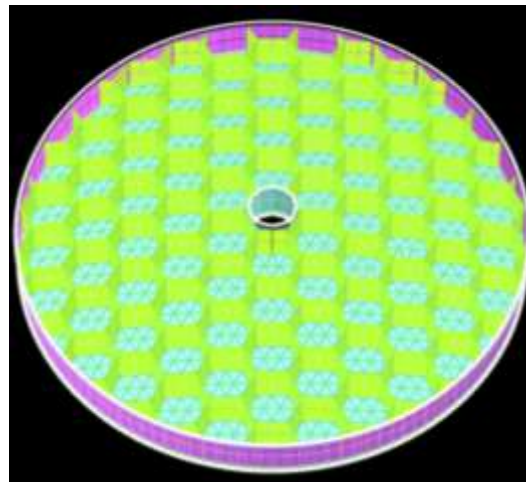
# TYPICAL INITIAL STEP TRY DIFFERENT CELL SIZES



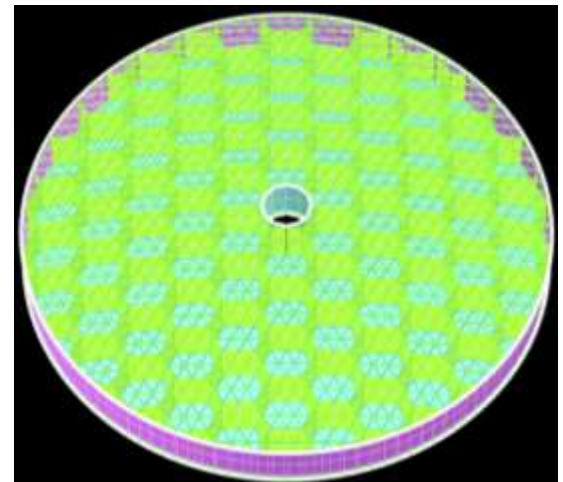
# **SAME GRID CAN GENERATE MULTIPLE CONSTRUCTION STYLES**



**NO ISOGRID**



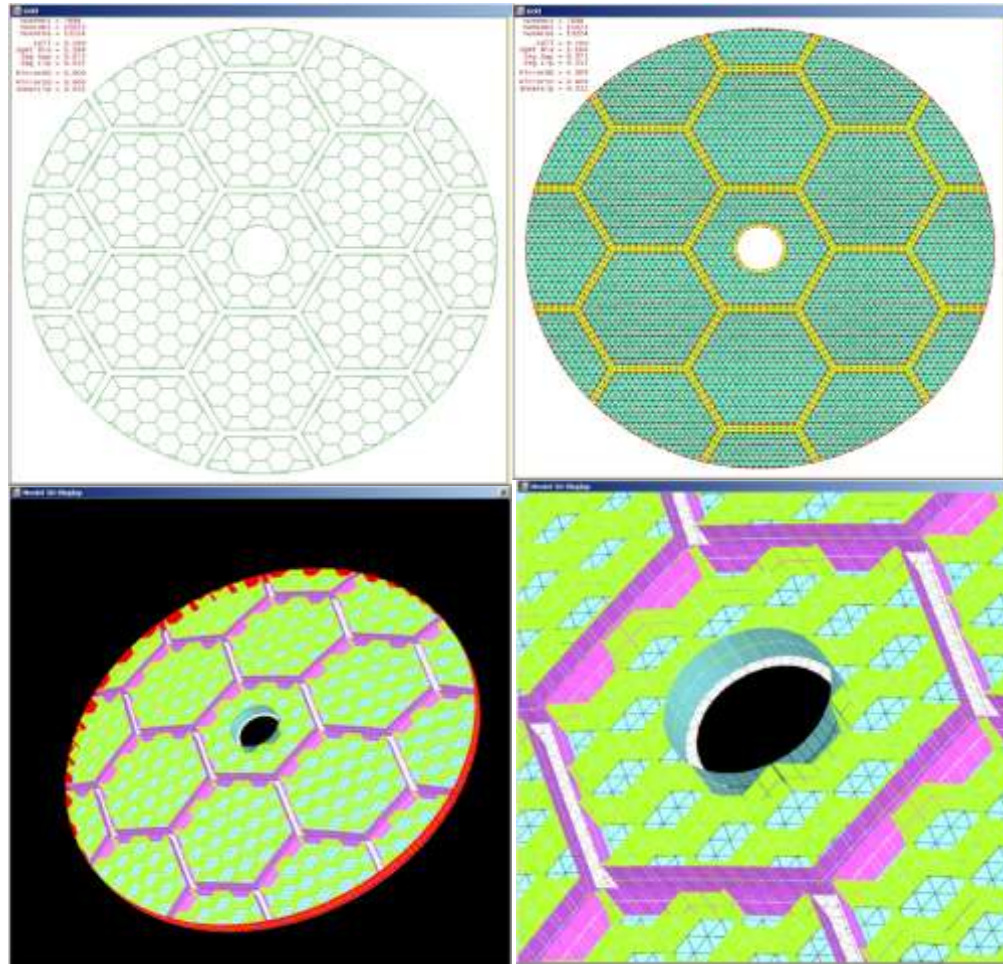
**FRONT ONLY ISOGRID**



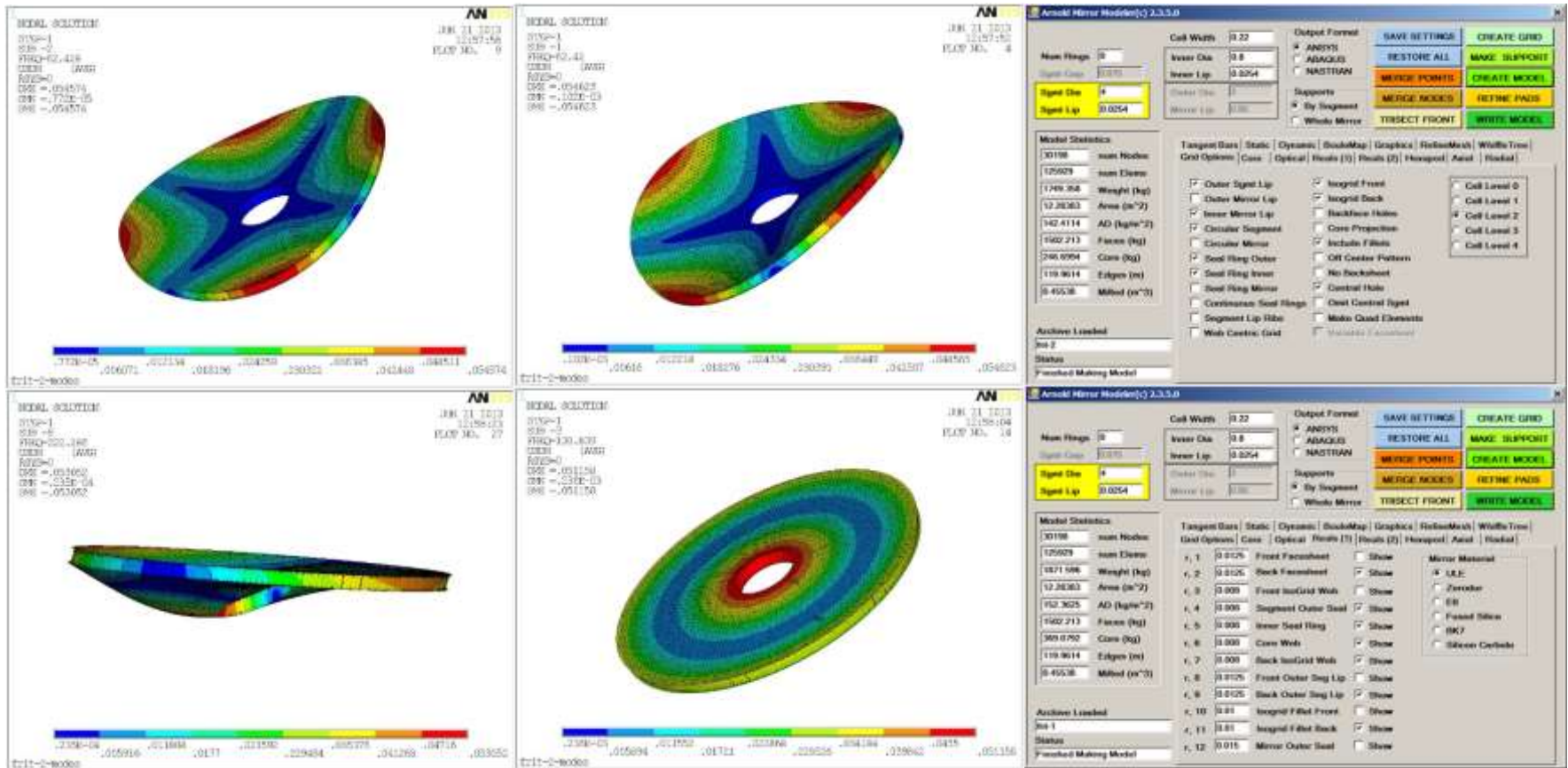
**FRONT & REAR ISOGRID**



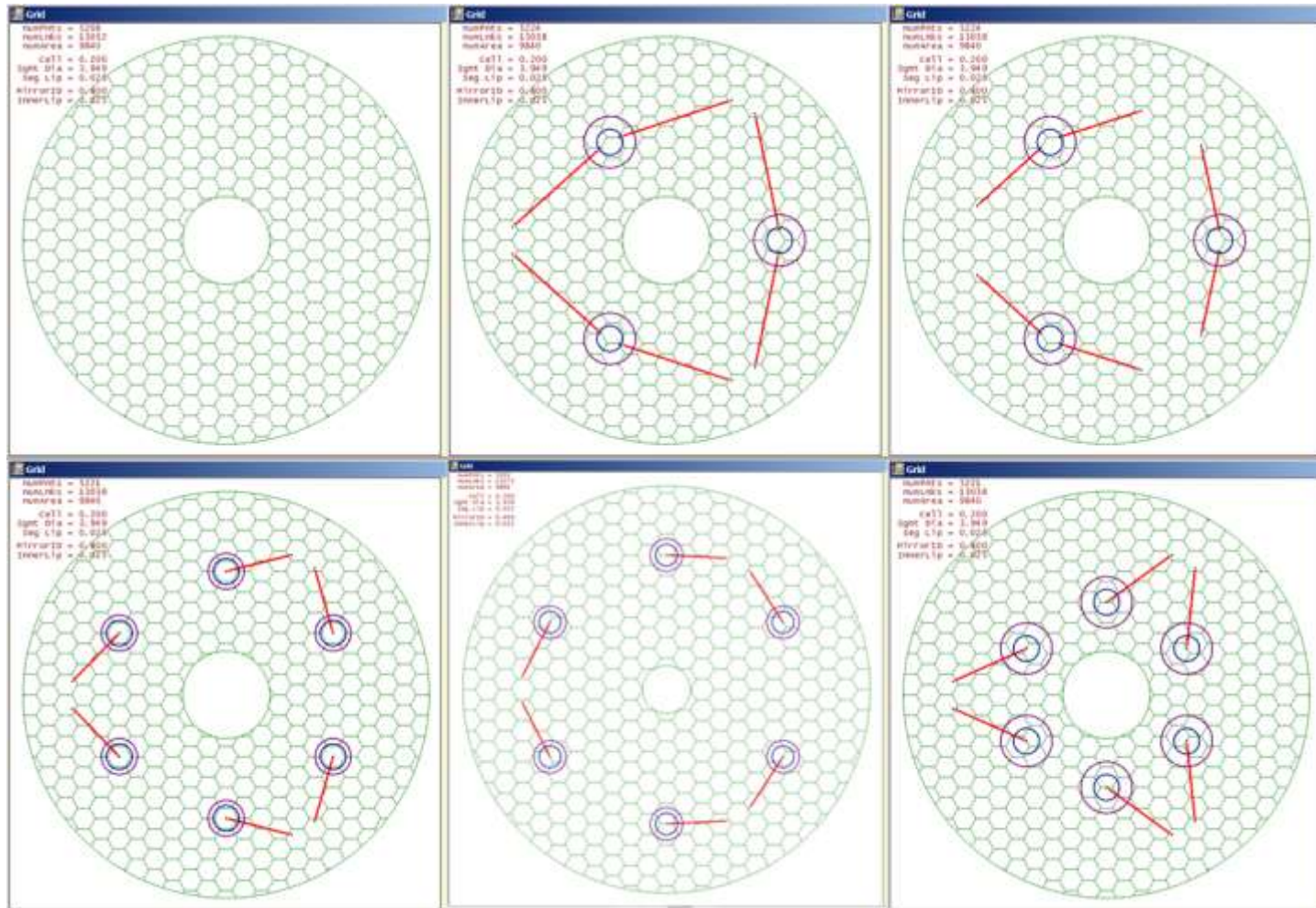
# MULTI-SEGMENT LTF CONSTRUCTION CAN BE MODELED





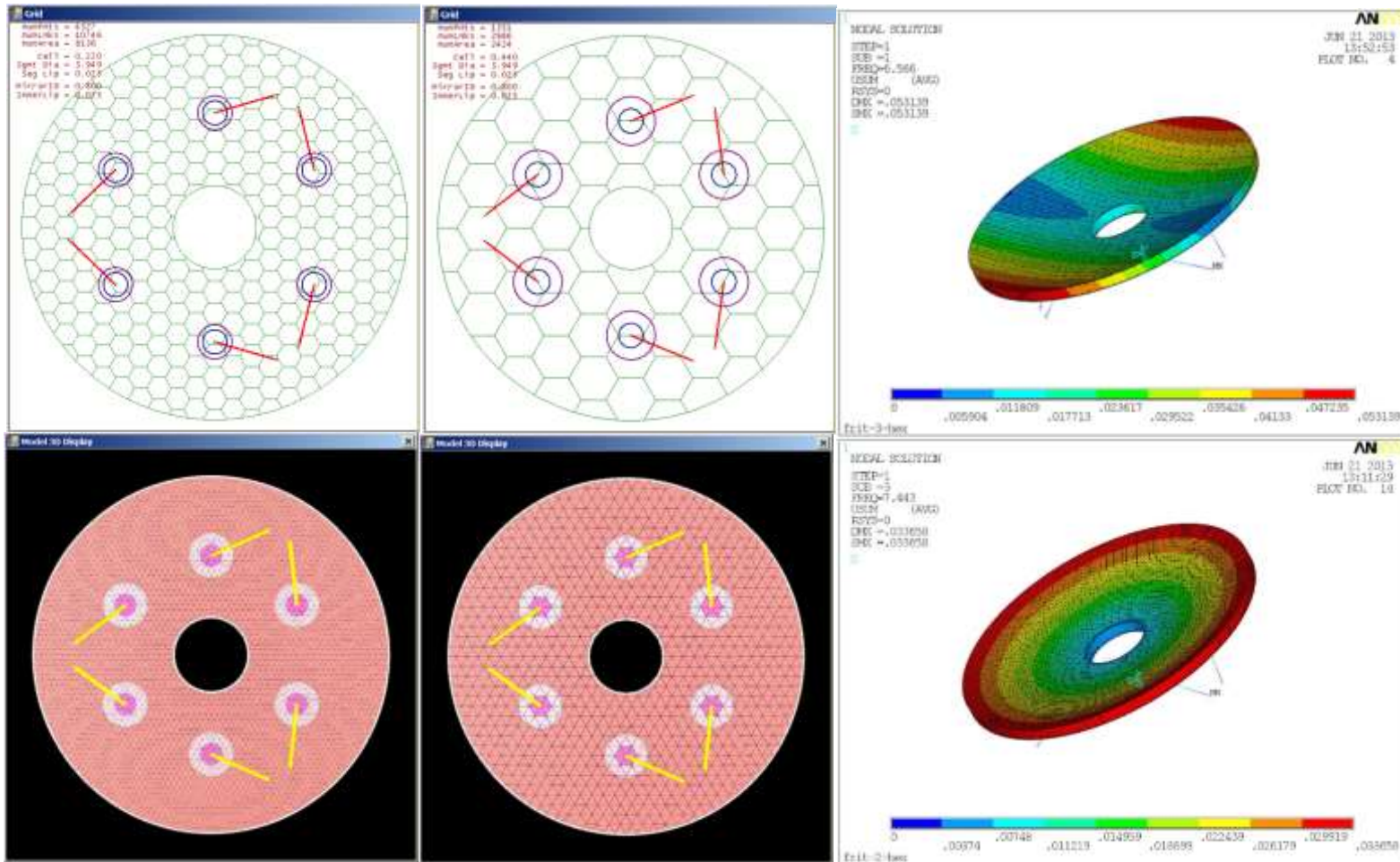


# STEP 3 - EVALUATE MIRROR & OPERATIONAL SUSPENSION

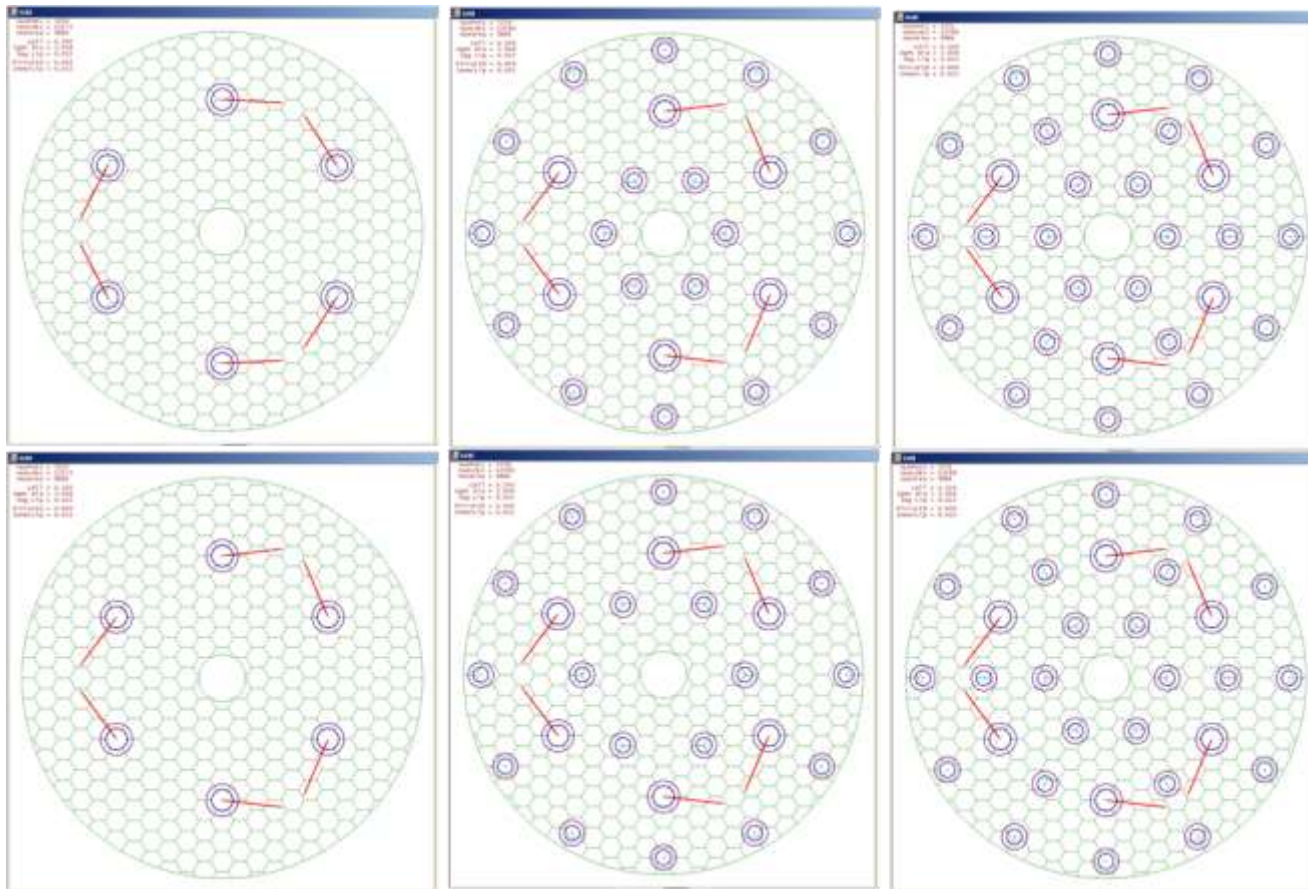




# EVALUATE CELL SIZE & SUSPENSION GEOMETRY

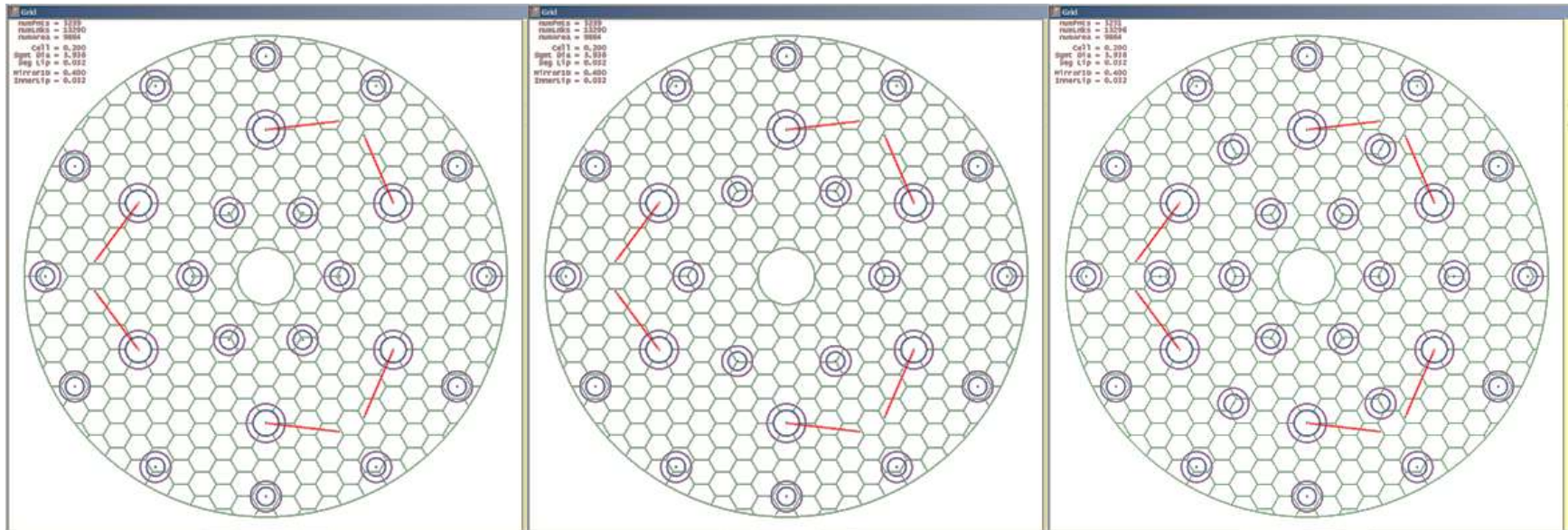


# STEP 4 – ADD AUXILLARY SUPPORT SYSTEM

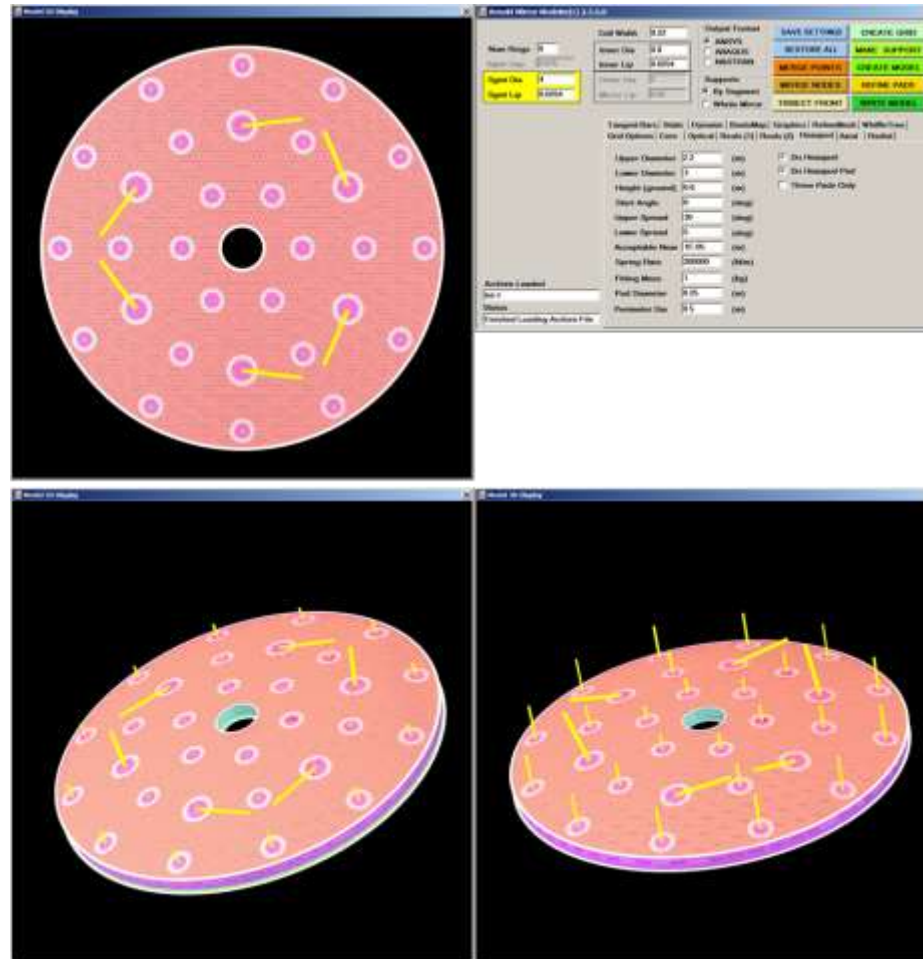




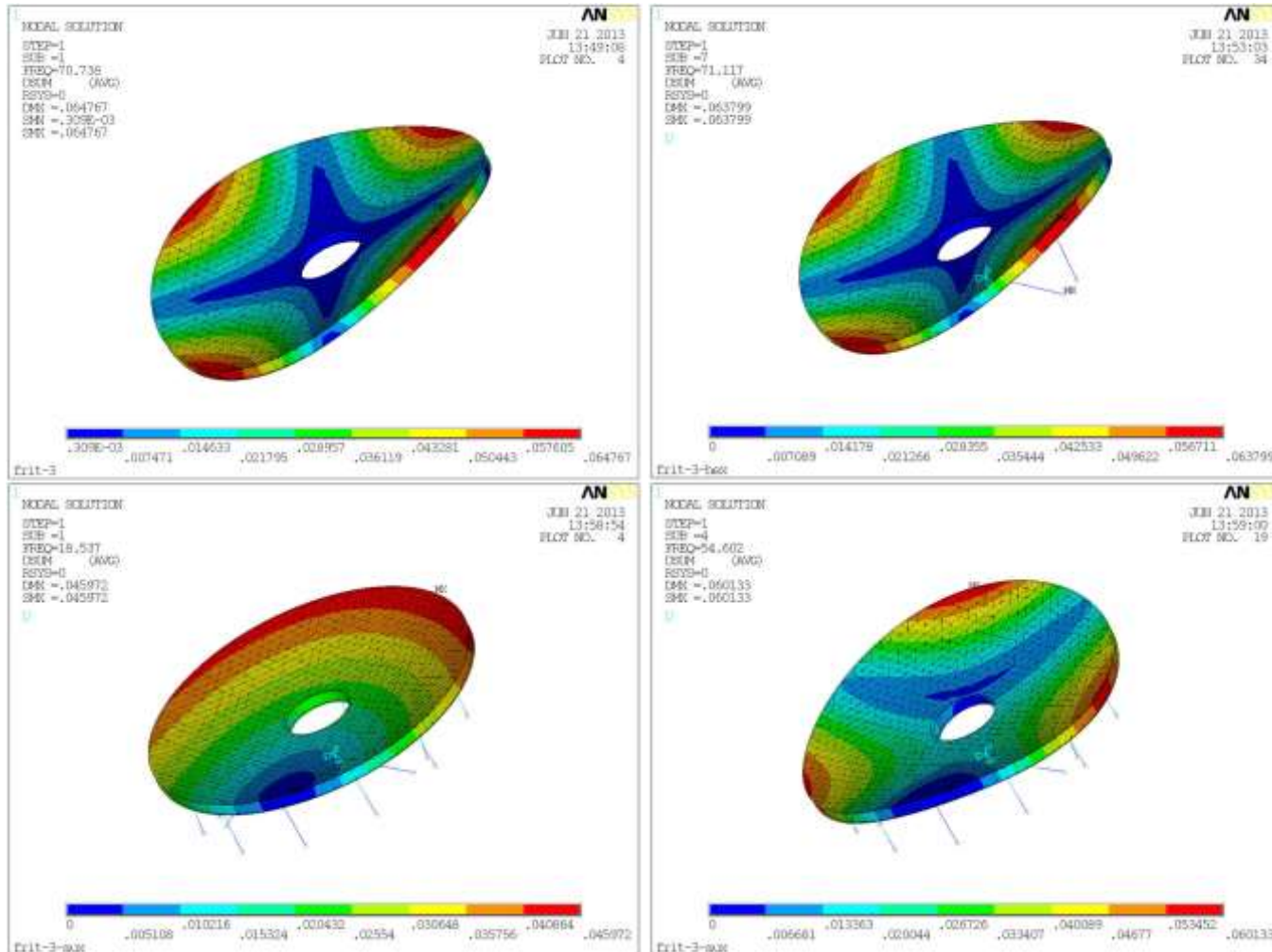
# TRY MULTIPLE VERSIONS OF AUXILLARY SUPPORT SYSTEM



**ADJUSTING GROUP DIAMETERS, NUMBER OF  
DIAMETERS AND STARTING ANGLES**

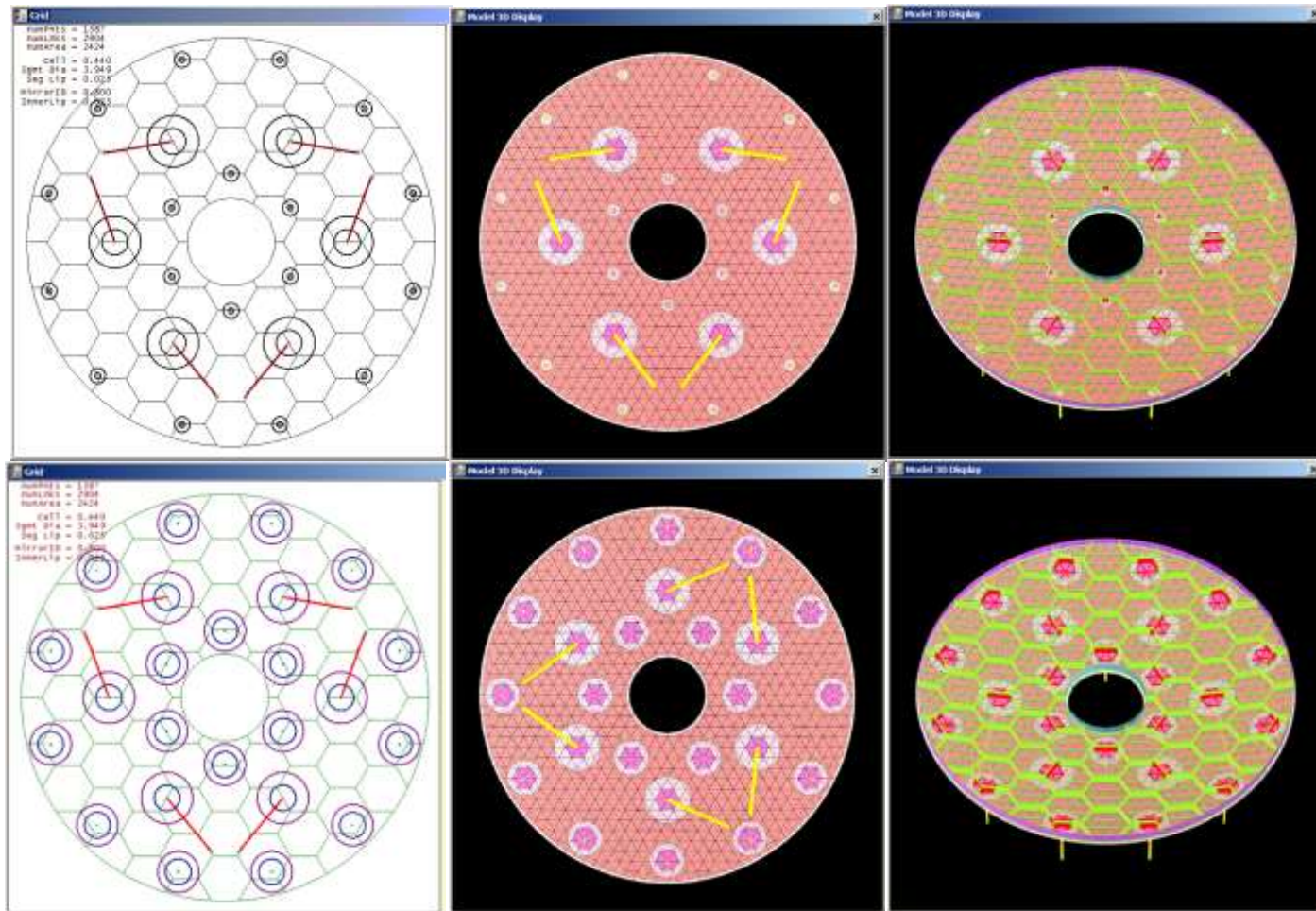


# ADJUSTING SUSPENSION PARAMETERS





# ADJUSTING PARAMETERS TO IMPROVE STIFFNESS





# SUMMARY

- **FEATURES AND CAPABILITIES OF MODELER TO MAKE THE PROCESS ECONOMICAL**
  - **REDUCED MODEL GENERATION TIME**
  - **ANY MATERIAL AND CONSTRUCTION METHOD SUPPORTED**
  - **CAN PRESET LOADS AND RESULT PROCESSING**
  - **ARCHIVE AND RESTORE ALL SETTINGS IN MODELER**
- **VALUE OF INTEGRATED DESIGN METHOD**
  - **CAN EVALUATE FEASIBILITY OF CONSTRUCTION METHOD**
  - **OPTIMIZE OPERATIONAL PERFORMANCE**
  - **LAUNCH SURVIVAL**
- **TIME PERMITTING, QUESTIONS & DEMONSTRATION**